U.S. Department of Defense

High-Level Architecture
Rules
Version 1.3

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Contents

1 Overview

1.1 Scope

The formal definition of the Department of Defense (DoD) High-Level Architecture (HLA) comprises three main components: the HLA rules, the HLA interface specification, and the HLA object model template (OMT) (see Clause 2). This document presents the first component of the HLA, the HLA rules. The other two components of the HLA formal definition are described in the following documents:

— *High-Level Architecture, Object Model Template, Version 1.3*
— *High-Level Architecture, Interface Specification, Version 1.3*

The overall objective of the DoD common technical framework, which includes the HLA, is to support interoperability and reuse. The HLA provides the structural basis for interoperability; most of the rules described in this standard have been included for that reason. Although the HLA is necessary for interoperability, it is not by itself sufficient. The other components of the common technical framework, the *Conceptual Models of the Mission Space and Data Standardization [B1]*, address other, equally important aspects of interoperability.

1.2 Purpose

This standard provides an overview of the HLA. General principles defining the HLA are described, and the set of rules that apply to HLA federations and federates are delineated. Each rule is then described and the rationale for its inclusion is provided.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply:

U.S. Department of Defense, *High-Level Architecture, Object Model Template , Version 1.3*, December 30 1997

U.S. Department of Defense, *High-Level Architecture, Interface Specification*, *Version 1.3, Draft 6*, December 30, 1997.

3. Definitions

API   application program interface

DoD   Department of Defense

FOM   federation object model

HLA   High-Level Architecture

MSRR   Modeling and Simulation Resource Repository

OMT   object model template

RTI   runtime infrastructure

SOM   simulation object model

4. Summary of the HLA Rules

Rules for federations are
1) Federations shall have an HLA federation object model (FOM), documented in accordance with the HLA Object Model Template OMT.
2) In a federation, all simulation-associated object instance representation shall be in the federates, not in the runtime infrastructure (RTI).
3) During a federation execution, all exchange of FOM data among federates shall occur via the RTI.
4) During a federation execution, federates shall interact with the RTI in accordance with the HLA interface specification.
5) During a federation execution, an instance attribute shall be owned by at most one federate at any time.

Rules for federates are
6) Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA OMT.
7) Federates shall be able to update and/or reflect any attributes and send and/or receive interactions, as specified in their SOMs.
8) Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOMs.
9) Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes, as specified in their SOMs.
10) Federates shall be able to manage local time in a way that will allow them to coordinate data exchange with other members of a federation.

5. Federation Rules

This clause describes the five rules that apply to HLA federations. Each rule is described along with the rationale for its inclusion.

5.1 Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT) (Rule 1).

The FOM shall document the agreement among federates on data to be exchanged at runtime and the conditions of the data exchange (e.g., updates to be sent when changes exceed a certain value). As such, the FOM is an essential element in defining a federation. The HLA does not prescribe which data are included in the FOM (this is the responsibility of the federation user and developer). The HLA does require that FOMs shall be documented in the format prescribed in *High-Level Architecture, Object Model Template* to support reuse of a federation (FOM) by new users for their own purposes.

The formalization of agreements for information exchange is an important element of the HLA. The HLA is domain independent and can be used to support federations for a wide variety of uses. The FOM shall be the means for specifying the data exchange for an application of the HLA. By formalizing the development of these agreements and requiring that the results be documented in a common format, the HLA provides the means for understanding the key elements of a federation and for assisting in the reuse of the federation, in whole or part. Such reuse is a goal of the HLA. In addition, the FOM provides the basis for some of the data used to initialize the RTI for the federation.

5.2 In a federation, all simulation-associated object instance representation shall be in the federates, not in the runtime infrastructure (RTI) (Rule 2).

One basic idea behind the HLA is to separate simulation-specific functionality from general-purpose supporting infrastructure. In the HLA, representation of simulated object instances (e.g., ownership of instance attributes, where "ownership" is defined as having the responsibility to update values) shall take place in the simulations (or, more generally, the federates); the RTI shall provides functionality similar to a distributed operating system, which is needed to support interaction of object instances across the federation. All simulation-associated instance attributes shall be owned by the federates, not by the RTI. The RTI may own instance attributes associated with the federation management object model.

Simulation functionality was separated from federation support services for several reasons. First, the RTI services are intended to be the basic set of broadly reusable capabilities needed to support federations across the widest range of DoD (and other) users. These are essentially coordination and management services supporting federation operations, time coordination, data distribution, etc. Because they apply across a range of HLA applications, these services can be provided most cost effectively as services to the applications rather as components of the applications themselves. Separation of the RTI services has the added advantage of freeing the federates to focus on their primary objective of representing object instances to meet the needs of a user or application domain. This approach frees the developers of simulations from investing time and resources in these basic common services. The RTI may use data about instance attributes and interactions to support RTI services (e.g., declaration management), but these data are merely used by the RTI, not changed.

5.3 During a federation execution, all exchange of FOM data among federates shall occur via the RTI (Rule 3).

The HLA shall specify a set of interfaces to services in the RTI to support coordinated exchange of instance

attribute values and interactions in accordance with the FOM for that federation. Under the HLA, intercommunication among federates in participating federations shall be executed by the exchange of data via the RTI services. Based on the FOM, federates shall identify to the RTI what information they will provide and require, along with instance attribute and interaction data corresponding to the changing state of object instances in the federate. The RTI shall then provide the coordination, synchronization, and data exchange among the federates to permit a coherent execution of the federation.

Ensuring that the right data is provided at the right times and that the data is used in a substantively correct way shall be the responsibility of the federates; the RTI shall ensure that the data is delivered to the using federates in accordance with their declared requirements (which data, reliability of transport, event ordering, etc.) to provide a common view of shared data across the federations as specified in the FOM.

To ensure that the coordination needs of the distributed applications (federations) are met in a consistent way across all participants in a federation and over the life of a federation execution, RTI services shall be used. If a federation were to exchange data representing state changes of shared object instances or interactions outside of the RTI service suite, the coherency of the distributed application would be violated. The reason for providing common runtime-infrastructure services to federations is to provide in common the needed basic functionality to permit coherency in data exchange among the simulations, thereby reducing the costs of developing and forming new federations.

5.4 During a federation execution, federates shall interact with the RTI in accordance with the HLA interface specification (Rule 4).

The HLA shall provide a standard specification for accessing RTI services to support interfaces between federates and the RTI (see *High-Level Architecture, Interface Specification*). Federates shall use these standard interfaces to interact with the RTI. This interface specification shall define how simulations interact with the infrastructure. However, since the interface and the RTI will be used for a wide variety of applications requiring data exchange of diverse characteristics, the interface specification says nothing about the specific federate data to be exchanged over the interface. Data exchange requirements between federates shall be defined in the FOM.

By requiring a standardized, common interface between federates and the RTI, along with a common application program interface (API), the HLA allows for independent development and implementation. Simulations can work independently and develop interfaces to the RTI without regard to RTI implementation, and RTI developments can proceed without explicit consideration of simulation development. The separation of the interfaces from the requirements for federate data exchange allows for the reuse of a common interface specification across the broad spectrum of DoD (and non-DoD) applications, with specific application needs tailored through the FOM mechanism.

5.5 During a federation execution, an instance attribute shall be owned by at most one federate at any time (Rule 5).

The HLA shall allow for different federates to own different attributes of the same object instance (e.g., a simulation of an aircraft might own the location of the airborne sensor while a sensor system model might own other instance attributes of the sensor). To ensure data coherency across the federation, the HLA shall allow at most one federate to own (have the right to change the value of) the attribute of an object instance at any time. The HLA shall also provide the mechanism to transfer ownership, dynamically during execution, from one federate to another.

By defining ownership at the instance attribute level and providing the tools to hand off ownership during execution, the HLA provides a flexible toolset for using various combinations of simulations to meet user needs.

6. Federate Rules

This clause describes the five rules that apply to HLA federates. Each rule is described, along with the rationale for its inclusion.

6.1 Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA OMT (Rule 6).

Federates shall be defined as simulations (a method for implementing a model over time) or other applications (including simulation managers, data collectors, live entity interfaces, and passive viewers) participating in a federation. The HLA shall require that each federate have an HLA simulation object model (SOM). The HLA SOM shall include those object classes, class attributes, and interaction classes of the federate that can be made public in a federation.

The HLA shall not prescribe which data are included in the SOM; this shall be the responsibility of the simulation developer. The HLA shall require that SOMs be documented in a prescribed format (HLA OMT).

A major of goal of the HLA is to support interoperability and reuse of simulations. The HLA shall provide this support by providing reuse at the level of simulations (or, more generally, federates), allowing access to the representations in those simulations.

Lack of cost-effective access to information about the object representations available in federates inhibits reuse. The requirement for a SOM addresses information access by requiring federates to document the minimum essential, salient aspects of their capabilities to allow for easy identification of the federate's potential application in new federations. Although the full set of information required by a potential user will go well beyond the SOM contents, providing easy access to characterizations of simulations based on reuse potential will enable users to decide more effectively whether to invest in further assessment of the simulations to their applications [through simulation descriptions available in the Modeling and Simulation Resource Repository (MSRR), simulation-specific documentation, or direct interaction with the simulation developer].

The HLA is based on the premise that developing and maintaining an accurate and usable statement of information supporting reuse is a high priority for individual simulation developers, whose success will be measured in part by the extent to which their simulation supports a wide variety of user applications.

6.2 Federates shall be able to update and/or reflect any attributes and send and/or receive interactions, as specified in their SOMs. (Rule 7).

The HLA shall allow federates to make object representations and interactions developed for internal use available as part of federation executions for external use with objects represented in other federates. These capabilities for external interaction shall be documented in the SOM for the federate. These federate capabilities shall include the obligation to export updated values of instance attributes that are calculated internally in the federate and the obligation to be able to exercise interactions represented externally (i.e., by other federates in a federation). By designing federates from the outset with the ability to present internal objects/attributes/interactions as public, the mechanisms for reuse of the simulation will be in place from the start.

6.3 Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOMs (Rule 8).

The HLA shall allow for different federates to own different attributes of the same object instance (e.g., a simulation of an aircraft might own the location of the airborne sensor while a sensor system model might own other instance attributes of the sensor). With this capability, it shall be possible to allow a simulation designed for one purpose to be coupled with one designed for another purpose to meet a new requirement. By building in the capability to transfer and accept ownership of instance attributes, simulations designed in accordance with the HLA provide the basic structural tools to become federates in the widest possible range of future federations. The instance attributes of a federate that can be either owned or reflected, and that can be dynamically transferred during execution, are documented in the SOM for that federate.

6.4 Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes, as specified in their SOMs (Rule 9).

The HLA shall permit federates to own (i.e., produce updated values for) attributes of object instances represented in the simulation and then make those values available to other federates through the RTI. Different federations may specify different conditions under which instance attributes will be updated (at some specified rate, when the amount of change in value exceeds a specified threshold such as altitude changes of more than 1000 feet, etc.) . Widely usable simulations shall be able to adjust the conditions under which they export their public instance attributes to support the requirements of different federations. The conditions applicable to the update of specific instance attributes of a federate shall be documented in the SOM for that federate.

6.5 Federates shall be able to manage local time in a way that will allow them to coordinate data exchange with other members of a federation (Rule 10).

The HLA time-management structure is intended to support interoperability among federates using different internal time-management mechanisms. The HLA shall support these capabilities provided that federates adhere to certain requirements necessary to realize each service. To achieve these goals, a *single*, unifying approach to time management is being developed to provide time-management interoperability among disparate federates. Different categories of simulations are special cases in this unified structure, and typically use only a subset of the RTI's full capability. Federates need not explicitly indicate to the RTI the time-flow mechanism (time stepped, event driven, independent time advance) being used within the federate, but shall utilize the RTI services (including time management) that are appropriate for coordination of data exchange with other federates.

ANNEX A (informative)
Bibliography

[B1] *Conceptual Models of the Mission Space and Data Standardization.*